

# Whey pre-treatment for value added whey products

Ken Burgess

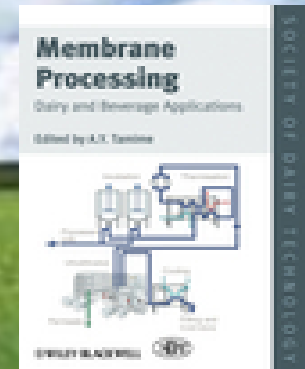


# Why pre-treatment for added value

1. UK whey products and processing challenges
2. Whey as a raw material and traditional pre-treatment
3. Producing a higher specification  
whey feed
4. Aspects of whey microbiology



# Whey Technology & Utilisation



SDT 70th ANNIVERSARY CONFERENCE  
June 12, 2013  
Reaseheath



# Whey based products: UK, 1980's to 2010's

## Whey based

Whey powder  
Demineralised whey powder  
Fat filled whey powder

Whey concentrate  
Sweetened condensed whey  
Hydrolysed whey syrup  
Demineralised, hydrolysed whey

## Whey Protein based

Delactosed whey  
WPC 35  
WPC 50/60  
WPC 76  
WPC 80  
WPI

## Lactose based

Edible lactose  
Refined edible lactose  
Pharmaceutical lactose  
Permeate powder



# Commercial whey processing challenges

## 1. Financial

- economy of scale imperative
- energy intensity

## 2. Technical

- variability of whey source
- whey pre-treatment
- process performance
- variability in product performance

## 3. Marketing

- establishing markets where whey based products offer distinctive consumer benefits and real added value



# Whey as a raw material

Milk & whey - similar but different

Composition

Physical structure

Microbiology



# Milk & whey; Composition, %

Component	Sweet whey (range)*	Milk (typical UK)**
Water	93-94	87.1
Lactose	4.5-5	4.7
Protein	0.8-1.0	3.3
Fat	0.2-0.5	4.0
Ash	0.5-0.8	0.7
Cheese fines	0.05-0.30	-

\* from GEA

\*\* from SDT Dairy Handbook



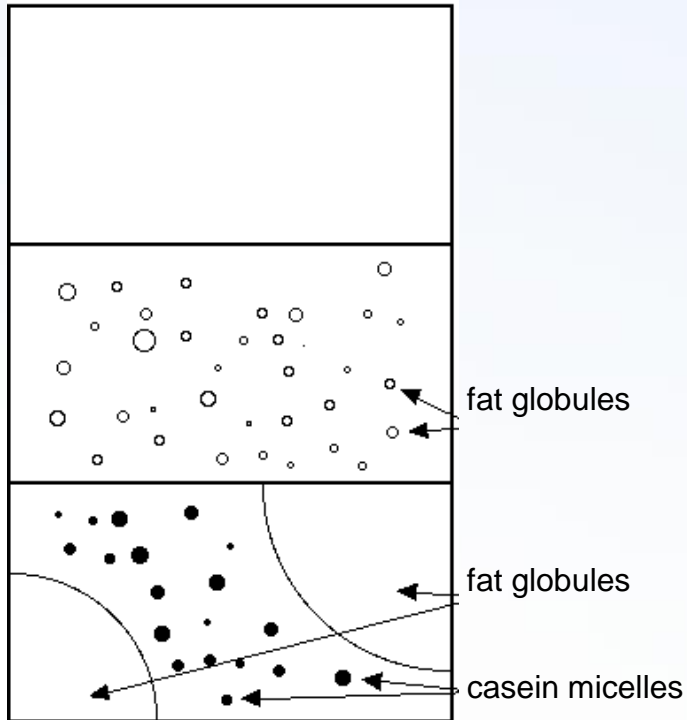
# Milk & whey; Structure

**Milk Structure**

x1  
opaque liquid

x1,000  
fat emulsion

x10,000  
casein suspension

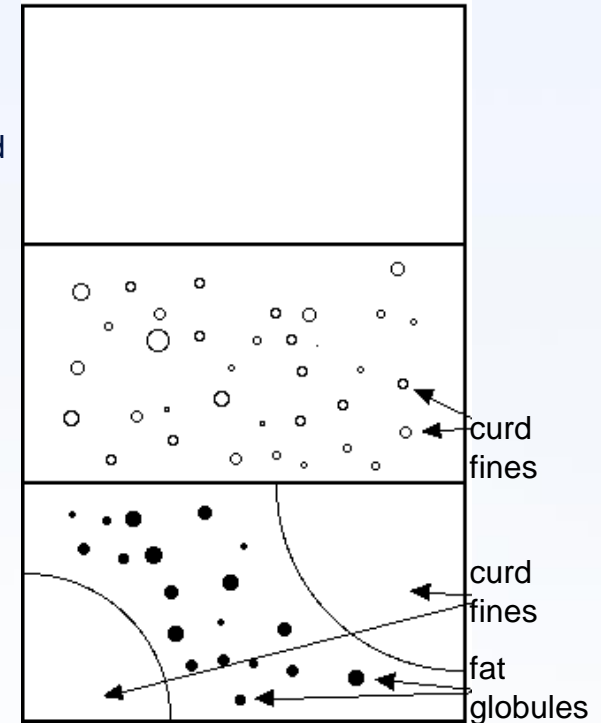


**Whey Structure**

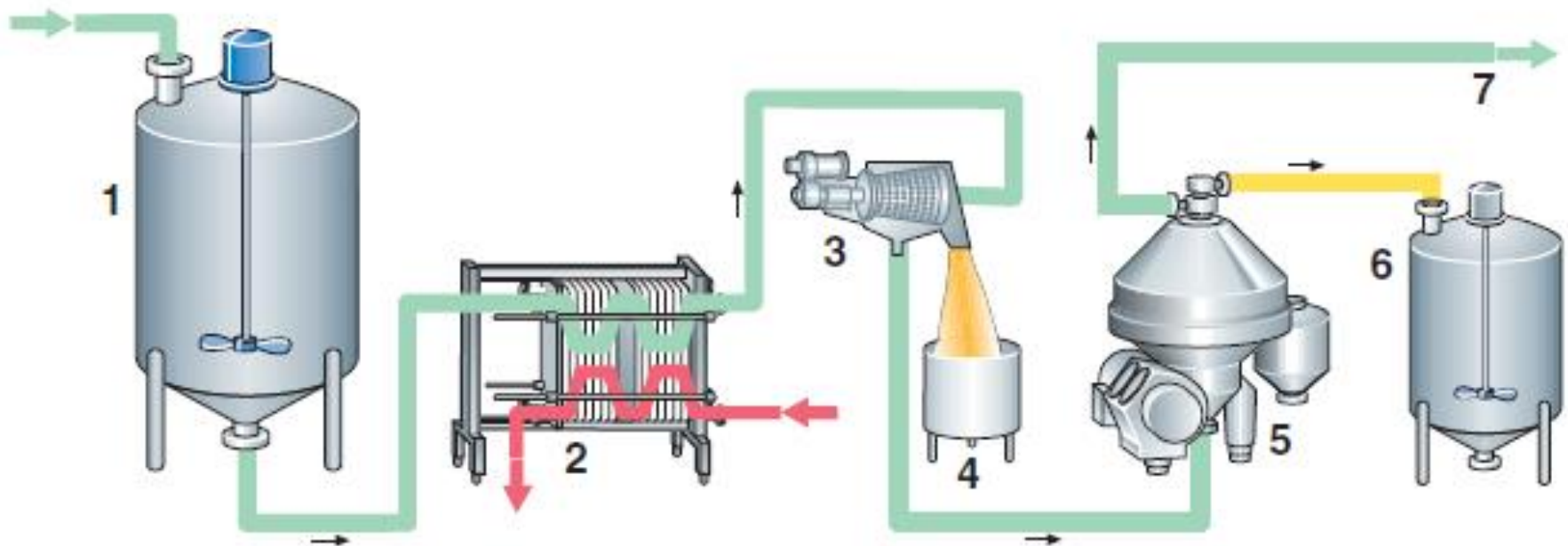
x1  
opaque liquid

x100  
fines  
suspension

x1,000  
fat emulsion



# Traditional whey pre-treatment



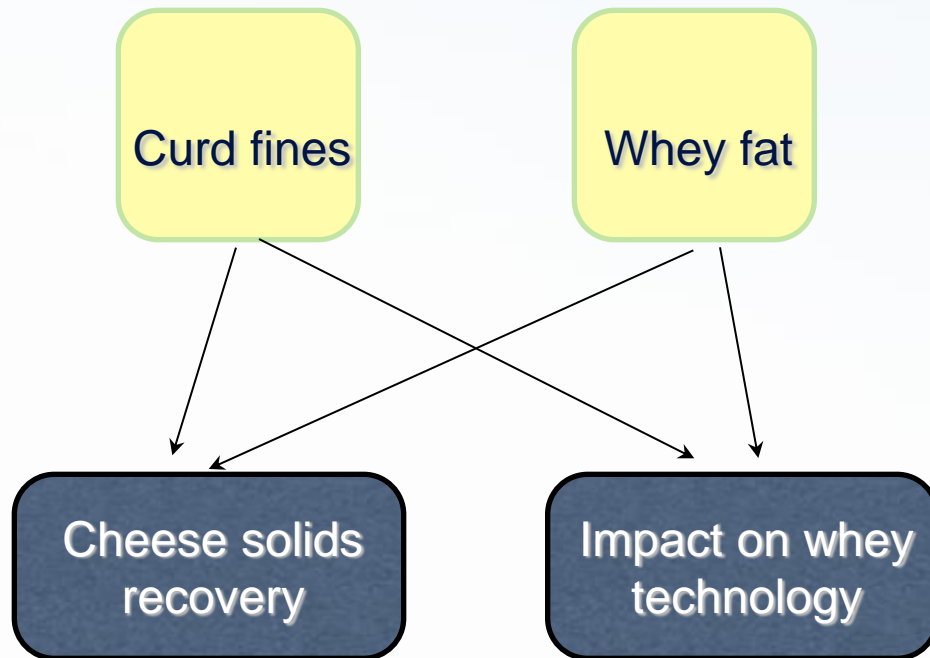
- 1 Whey collecting tank
- 2 Plate heater
- 3 Rotating strainer
- 4 Fines collecting tank
- 5 Whey cream separator
- 6 Whey cream tank
- 7 Whey for further treatment

- Whey
- Fines
- Cream
- Heating medium

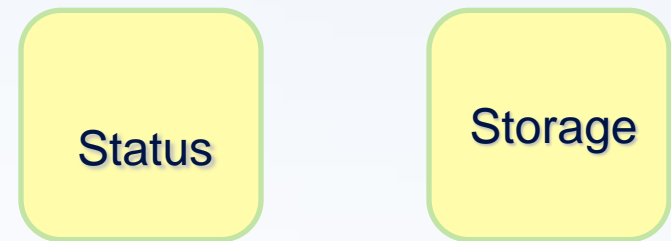


# Whey pre-treatment for added value

## Separation processes



## Microbiology



# Curd Fines: Measurement

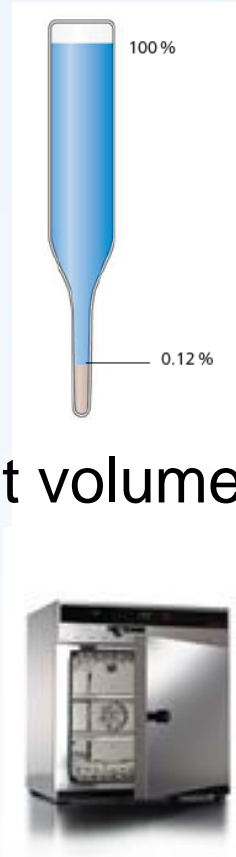
Imhoff cone



Sediment



Centrifuge



Wet volume

Dry solids



# Curd fines and whey fat values

Cheese Vat	Curd fines (mg/kg)	Whey fat (%)	Reference
Vat 1	179	0.26	NIZO
Vat 2	145	0.28	NIZO
Vat 3	105	0.22	NIZO
Vat 4	97	0.26	NIZO
Vat 1	17-287	0.26-0.33	Moorepark
Vat 2	34-353	0.18-0.35	Moorepark
Vat 3	31-886	0.44-0.80	Moorepark



# Curd fines: effect of pumping

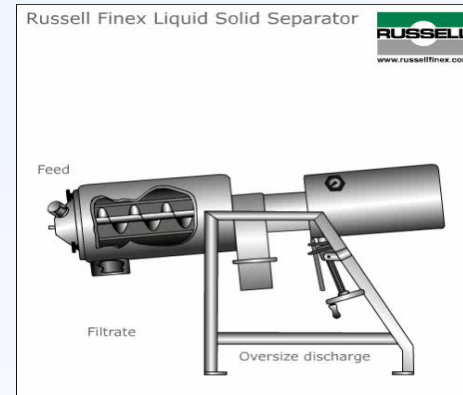
Curd fines in vat (ml)	Curd fines after whey removal (ml)	Reference
1.75 - 2	4	Tetra Pak
1.75 - 2	3.5 - 4	Tetra Pak
2	6	KBA



# Fines screens/sieves



Qualtech Curd Maximiser



Fines sieve typically recovers  
30 to 60 % of the fines

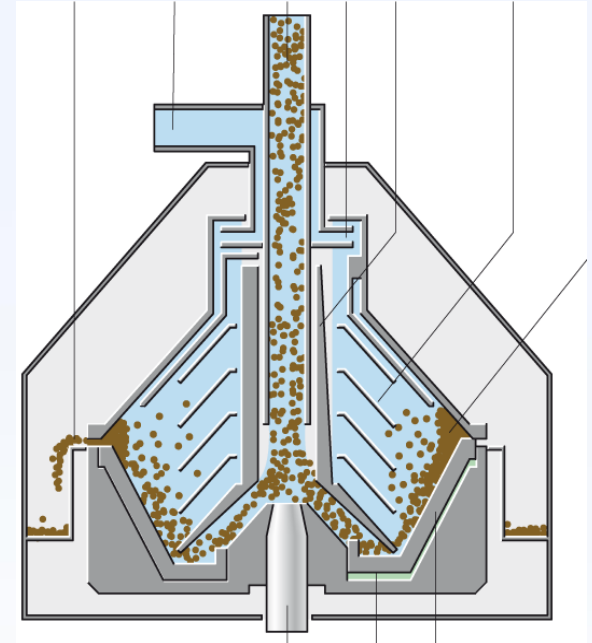


# Whey clarifier

Clarifier recovery approx. 85%



The Disk Centrifuge

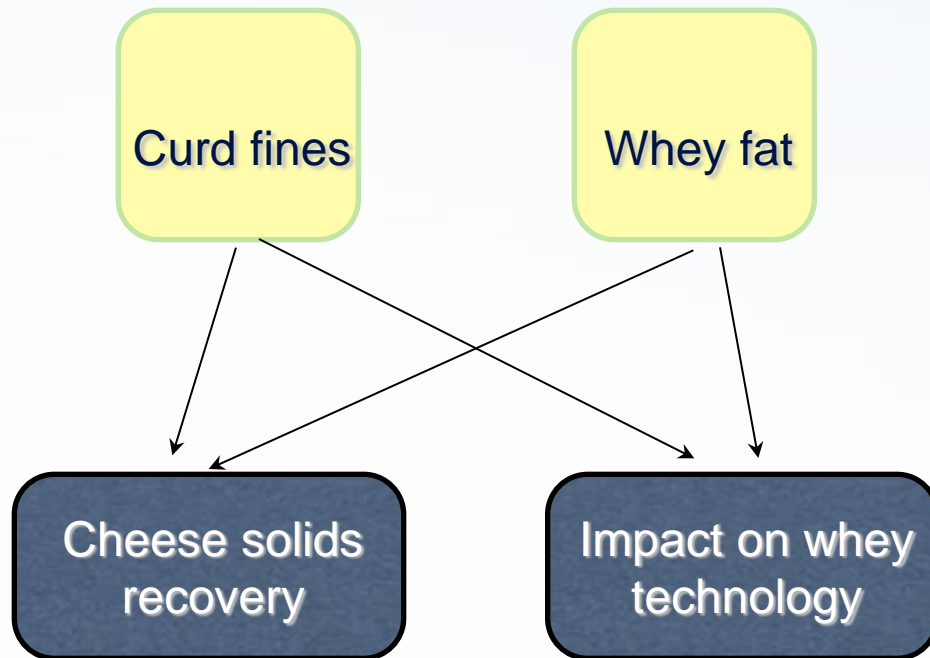


Clarified whey curd fines mostly 15-30 mg/l (max 50 mg/l)

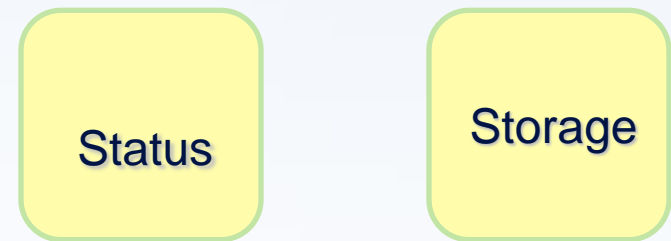


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# Whey fat: measurement

**For whey fat:**

**Rose Gottlieb value > Gerber value**



Gerber



Rose Gottlieb



FTIR

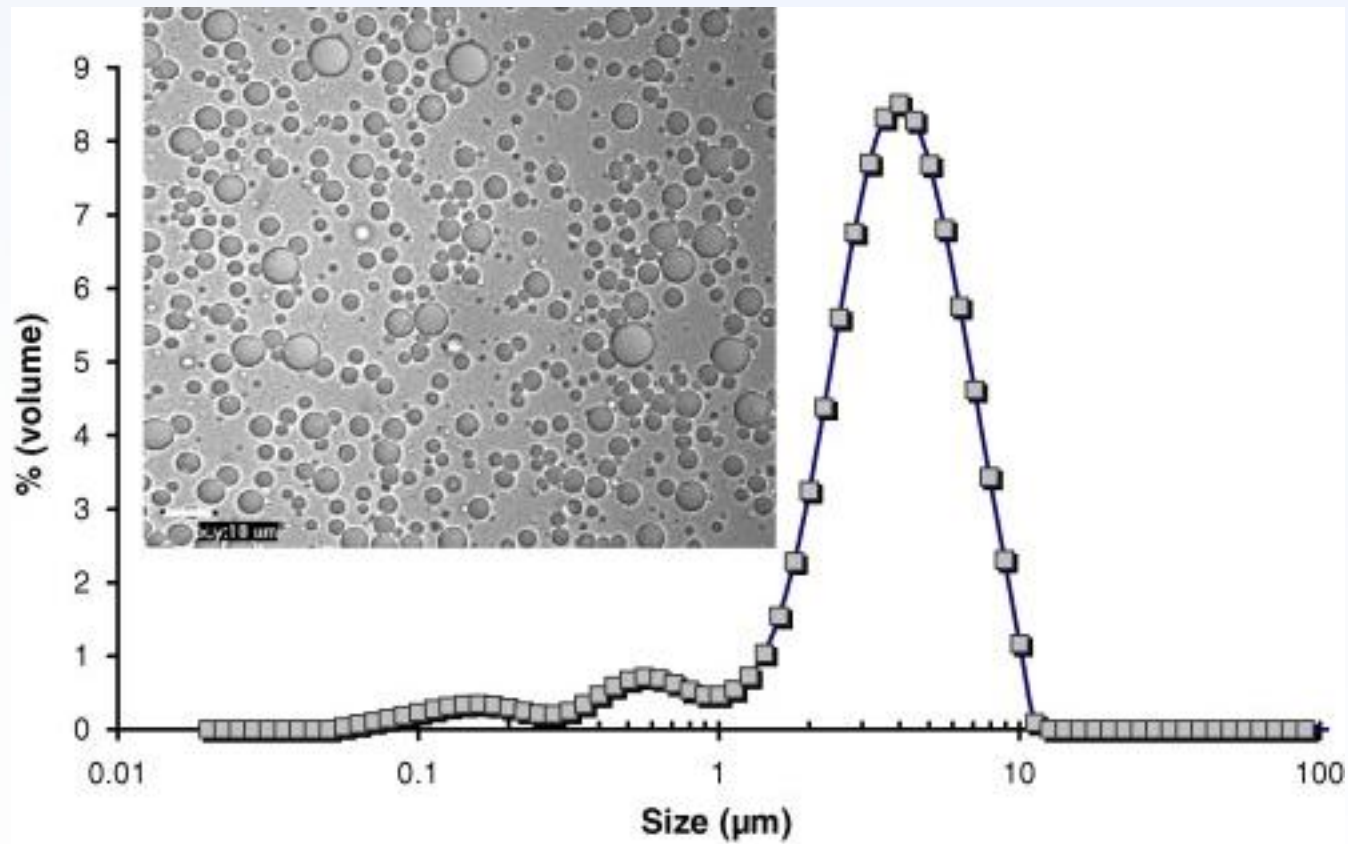


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# Milk fat: fat structure

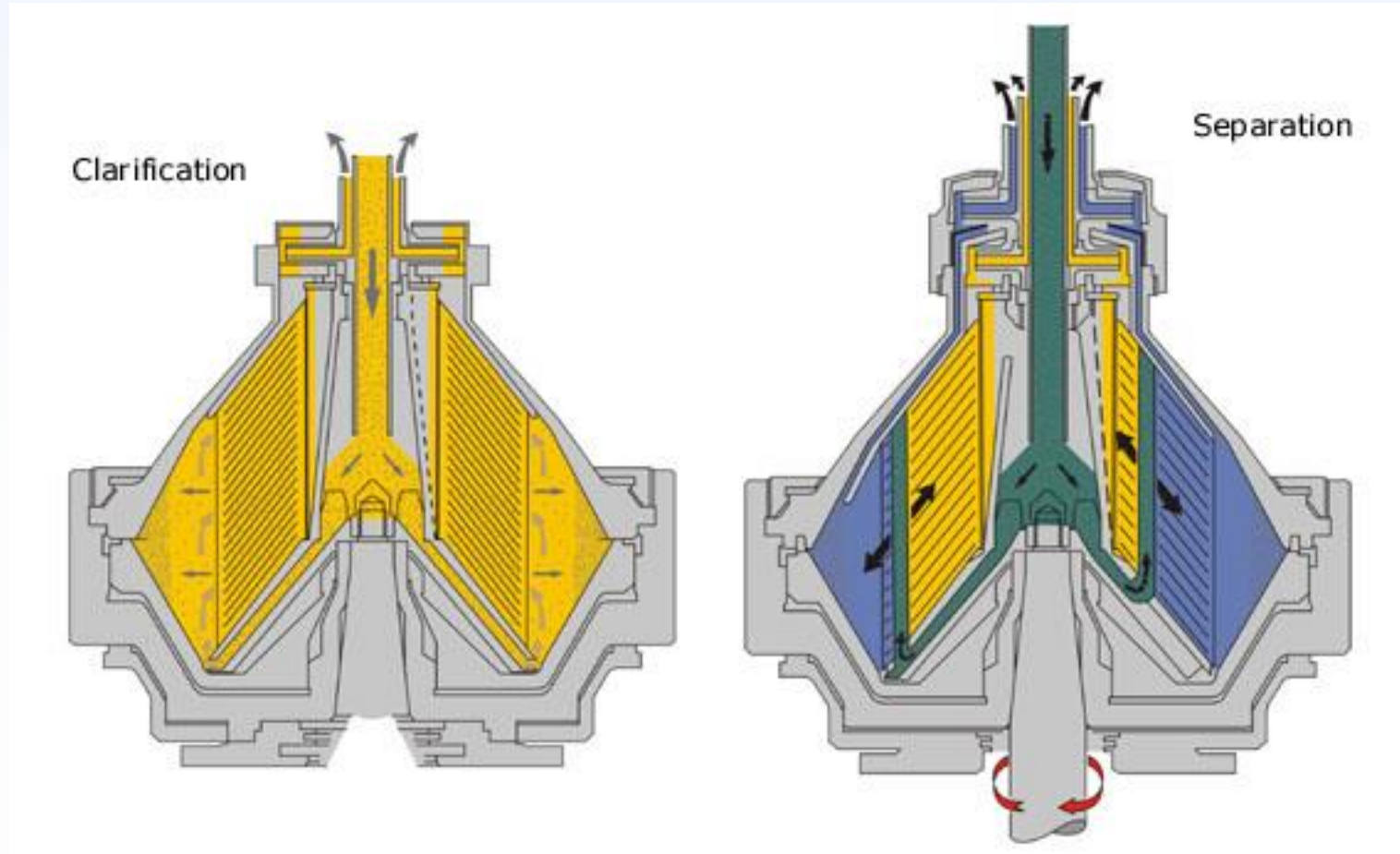


# Whey fat: fat structure

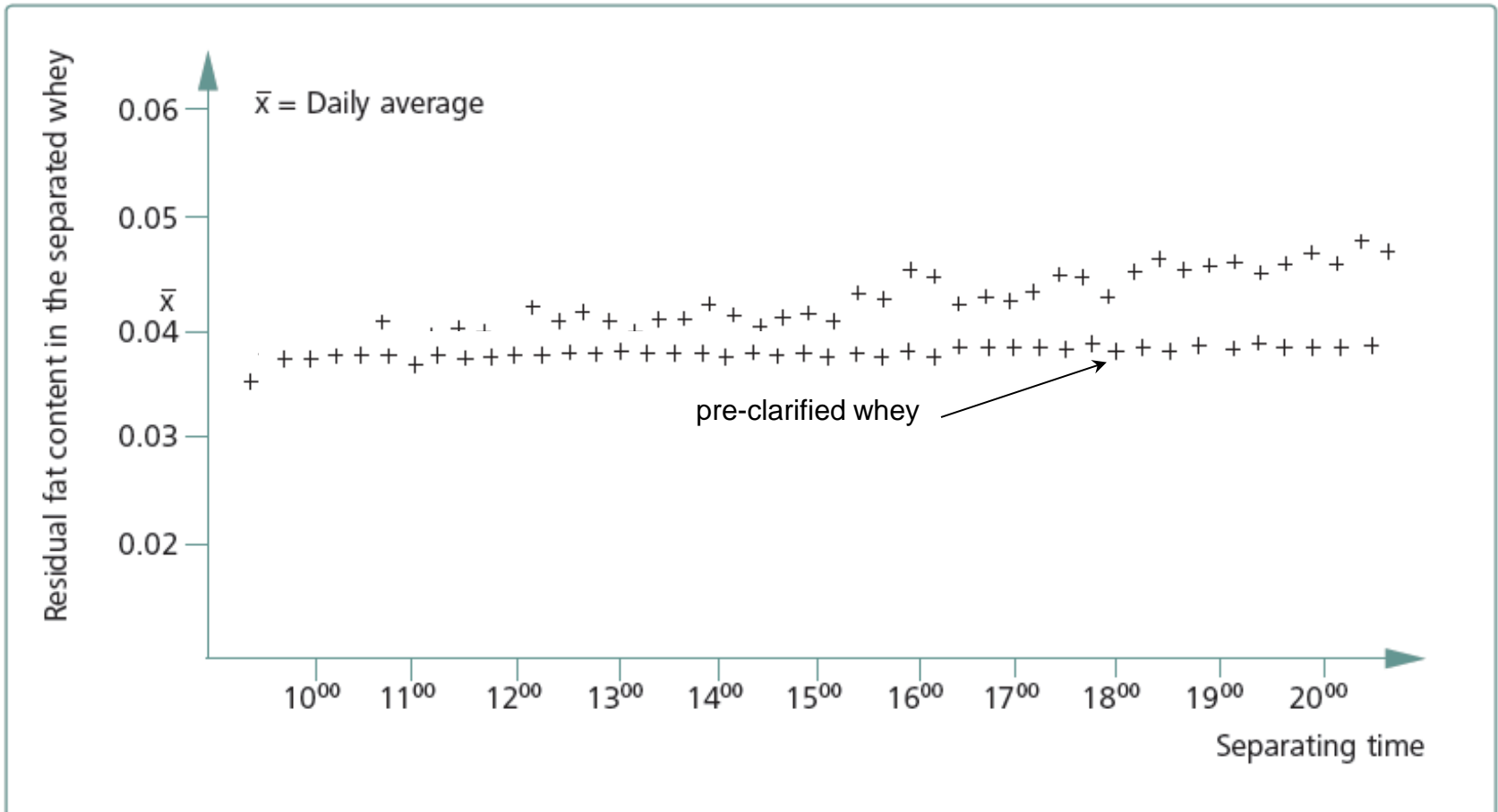
De Wit	Johnston	Lipatov	Kamath & Morr
large proportion (c.50%) of small globules ( $<1\mu$ )  remainder of fat bound to proteinaceous material  enriched in phospholipids and milk fat globule membrane material	small % in globular form  higher proportion of free fat  size of intact globules decreases during cheesemaking	most of fat globules (98%) $<2.5\mu$  large proportion of fat globules (72%) $<2\mu$	LDLF (95%)  $<1\mu$ globules dispersed in non-lipid matrix  MDLF (5%)  clear fat  HDLF (0.1%)  fat within a gel matrix



# Centrifugation: Separation & Clarification



# Whey fat: separation efficiency trend



# Importance of separated whey fat

**Whey**                      →                      30 X                      →                      **WPC 80**  
6% solids                      CF                      25% solids

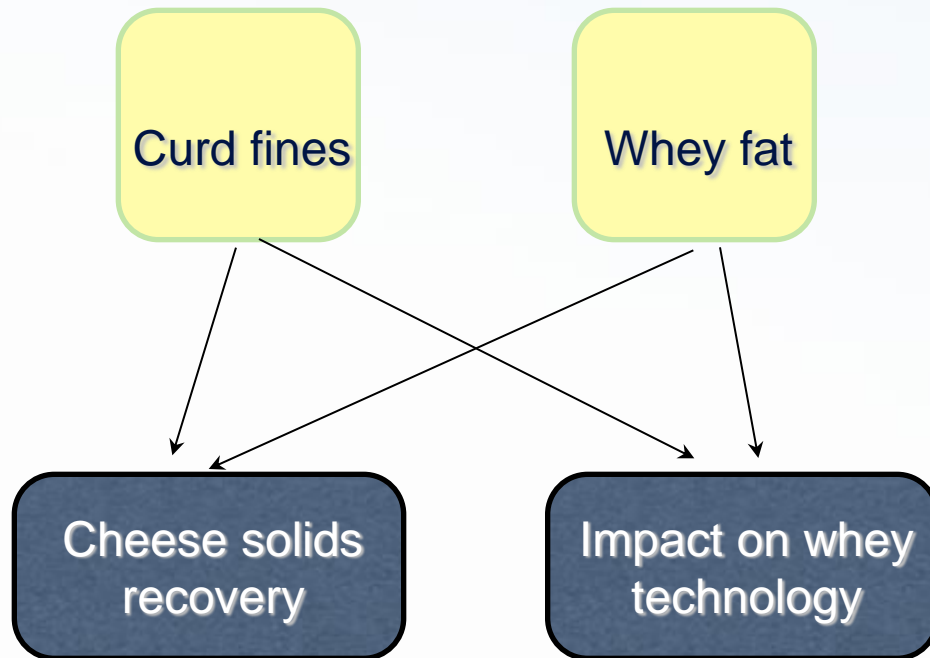
0.05% fat	0.06% fat	0.07% fat
0.8% fdm	1.0% fdm	1.2% fdm

1.50% fat	1.80% fat	2.10% fat
6.0% fdm	7.2% fdm	8.4% fdm

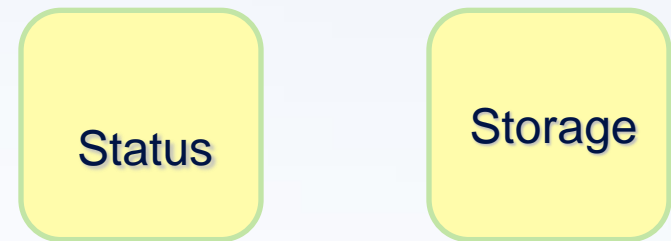


# Whey pre-treatment for added value

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# Whey microbiology: key genera in milk

Heat-resistant (survive 60 C for 20 min)	Thermoduric (survive 63 C for 30 min)	Spores (survive 80 C for 30 min)
<b><i>Streptococcus faecalis</i></b>	<i>Microbacterium spp.</i>	<b><i>Bacillus spp. spores</i></b>
<i>Lactobacillus spp.</i>	<i>Micrococcus spp.</i>	<i>Clostridium spp. spores</i>
<i>Corynebacteria spp.</i>	<i>Alcaligenes spp.</i>	

Dairy Powders & Concentrated Products, SDT  
Technical Series



# Faecal streptococci: food context

- Enterococci or 'Lancefield Group D' streptococci
- Indicator of faecal contamination
- More persistent than coliforms (tolerant of 6.5% salt)
- Indicator of poor sanitation in dairy plant
- Concern over antibiotic resistance & gene transfer to pathogens
- 'Crossroads of food safety'

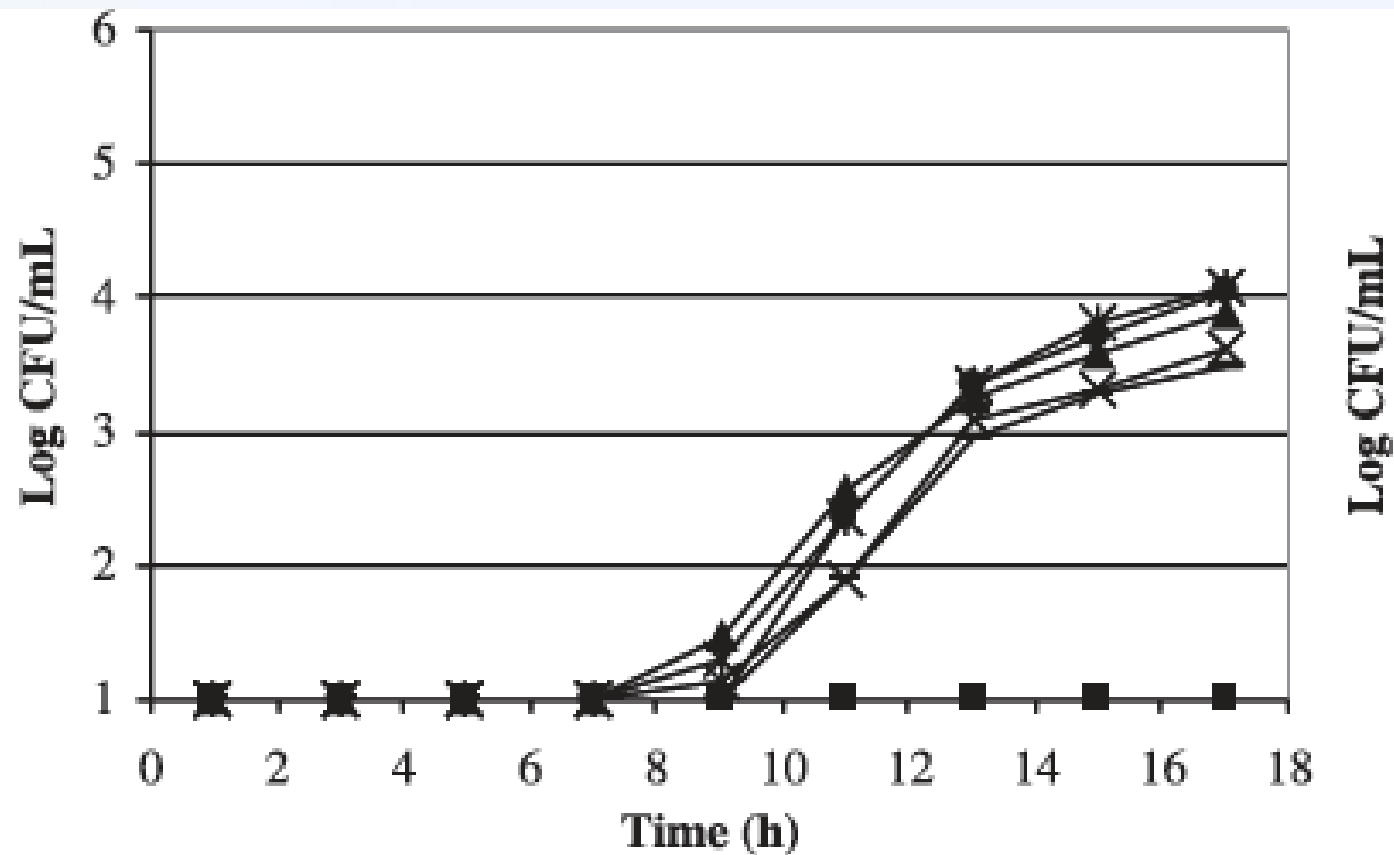


# Faecal streptococci in whey

- Most resist 62.8°C for 30 minutes
- *S.faecalis*, *S.faecium*, *S.durans* in whey powder
- Part of raw & pasteurised milk microflora
- Naturally occur in whey
- Optimum growth at 42-44°C
- Growth markedly limited @ 5-8°C



# Spore counts in pasteurised milk



Scott et al, IJDT

Ken Burgess Associates

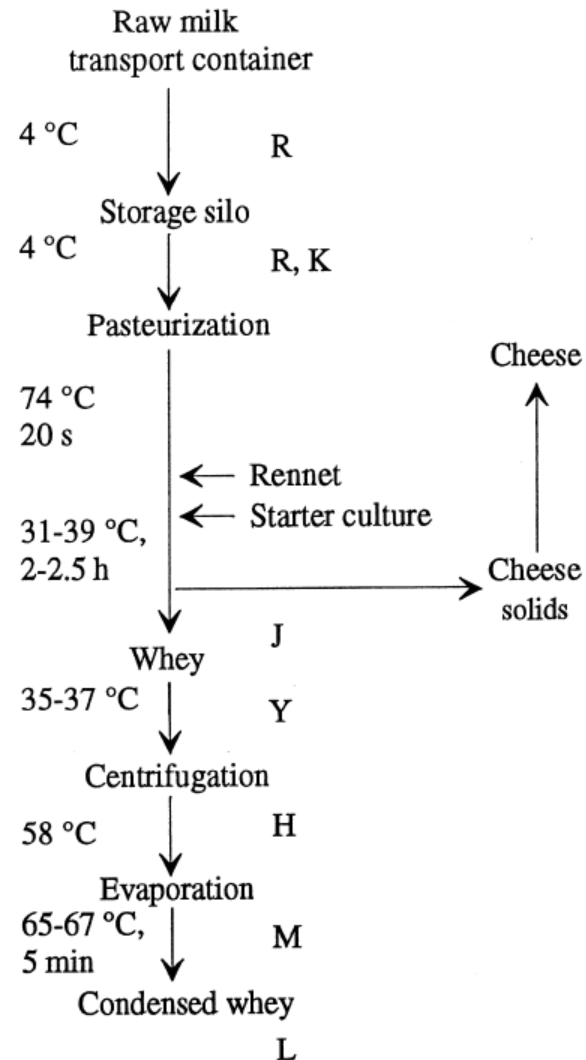


# *B.cereus* in whey study

## *Bacillus cereus* in a whey process



Pirttijarvi et al, 1999



Ken Burgess Associates



# *B.cereus* in whey study

- *B.cereus* more prevalent in whey samples (26%) cf. raw milk (3%)
- *B.cereus* increased through process
- Evidence of *B.cereus* spores adhering to surfaces, & not fully removed by CIP
- *B.cereus* population in whey separate from that in raw milk (whey strains weakly casein hydrolytic)
- Whey strains of *B.cereus* showed no growth  $< 8^{\circ}\text{C}$ , with milk strains showing no growth  $< 5^{\circ}\text{C}$



# Thermotolerant bacteria in a WPC process

Raw milk



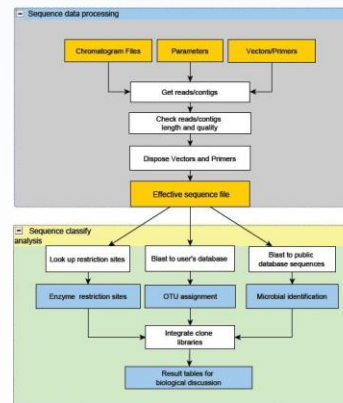
Pasteurised milk



Whey



Whey Protein Concentrate



16S rRNA

gene typing



# Thermotolerant bacteria in a WPC process

Extent	Thermotolerant bacteria isolated
Dominant (all 4 stages)	<i>Bacillus licheniformis</i> , <i>Microbacterium lacticus</i> , <i>Staphylococcus warneri</i> , <i>Enterococcus durans</i>
Frequent (2 or more stages)	<i>Bacillus subtilis</i> , <i>pumilus</i> <i>Staphylococcus haemolyticus</i> , <i>Micrococcus luteus</i>
Whey/WPC	Bacilli, Staphylococci, Streptococci, <i>Enterococcus faecalis</i> , <i>Enterococcus faecium</i> <i>Microbacterium phyllosphaerae</i> , 9 other isolates



# Whey handling for hygiene

- Control microbial load of the cheesemilk
- Pasteurise whey immediately after production
- Minimise holding time between whey production & processing
- When holding whey, cool or hold hot
- Maintain same good cleaning & disinfection practices for whey handling as for liquid milk



# Whey storage: recommended conditions

Storage Condition	IDFA	GEA Niro	Harper	Jervis
Uncooled	< 2 hours	< 1 hour	'minimise'	-
Chilled storage	< 7°C	< 10°C (up to 10 hours)	< 4.4°C	< 5°C
Hot storage	>63°C	-	> 50°C (up to 6 hours)*	> 63°C

\* after 6 hours at > 50°C, changes in whey protein & growth of thermophiles

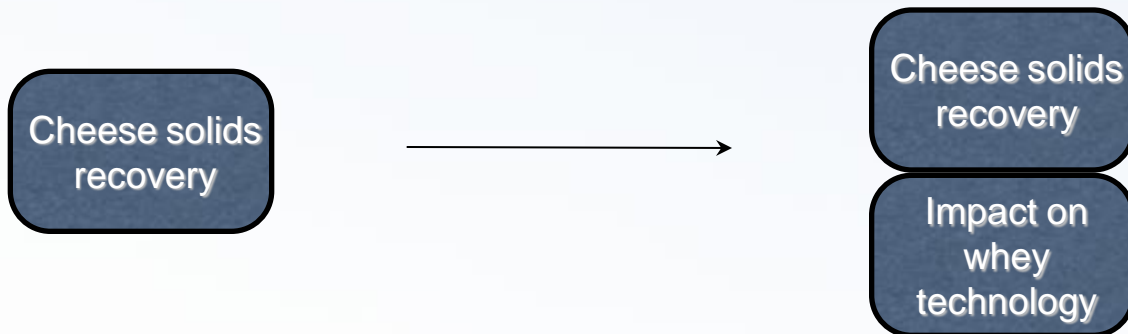


# Whey pre-treatment : Summary

## 1. Milk & whey - similar but different



- **Curd fines & whey fat: context**



- **Whey microbiology**

Whey microflora	Whey storage
Faecal streptococci	Strategy to control thermodurics
<i>B.cereus</i>	Key temperature is 8°C



# Why pre-treatment for added value

A concluding thought (Harper):

‘Those who treat whey as an “orphan” by-product can expect to produce whey as only a relatively low-value commodity’



Thank You

The bottom of the slide features several overlapping, wavy lines in various shades of blue and white, creating a sense of motion and depth.